the process is obviously multi-variate, then other methods are necessary. An exponential model with a time-dependent rate is one approach having a multiple linear regression solution. The exponential equation takes the form

$$x_t = x_0 \exp\left[-\int_0^t f(t)dt\right]$$

where $f(t)$ is a linear sum of several cumulative time-dependent variables such as temperature, rainfall, vapor pressure deficit, etc. Taking logarithms to the base e gives:

$$\ln(x_t/x_0) = a_0 + a_1\int f_1(t)dt + \ldots. + a_n\int f_n(t)dt,$$

a multiple linear regression of $\ln(x_t/x_0)$ on accumulated variables (e.g. heat units, cum. rainfall, etc. Similar reasoning can be applied to "logistic" equation,

$$p = 1/\{1 + \exp\left[-\int f(t)dt\right]\},$$

where p is a proportion in some growth or mortality process. This equation may be linearized as

$$\ln[(1-p)/p] = a_0 + a_1\int f_1(t)dt + \ldots. + a_n\int f_n(t)dt$$

which is a multiple linear regression of $\ln[(1-p)/p]$ on accumulated environmental variables.

Agricultural Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Lake Alfred, Florida 33850.

DETERMINING ECONOMIC RELATIONSHIPS

W. L. Sterling

The term "action level" is proposed for general use as the estimate of the economic threshold. It might be defined as an empirically determined pest density at which some action tactic should be employed to prevent losses unacceptable to the producer or his decision-maker. "Action level" could thus be used to describe the pest densities at which management decisions are being made in most of our fledgling management programs. However, the continuing goal of pest management researchers should be to obtain the definitive economic thresholds and economic injury levels.

Some of the factors which should be considered in establishing economic thresholds include climatic conditions, phenological events, cultivars, crop cultural practices, economics, externalities, aesthetics, cumulative damage by all pests, plant compensation, insecticide resistance, geographical distribution of pests, produce quality, soil types, spatial dispersion, pest dispersal, natural mortality factors and pest density.

Department of Entomology, Texas A&M University, College Station, Texas 77843.

PRODUCING DECISION AND DELIVERY SYSTEMS

G. P. Dively

Presented is an overview of decision and delivery systems used today in the 38 USDA-Extension funded IPM pilot projects, with emphasis on research needs.

Most projects rely on field scouting and trapping devices as means of providing decision-making information. Since the grower must ultimately be convinced that the risks and cost of scouting outweighs the benefits, much research needs to be done in developing more practical scouting techniques. Catch/damage relationships and the effects of weather on trap catch must be further investigated before traps can be fully implemented as decision-making tools.

Lack of decision-making methodology is perhaps the most limiting factor in developing IPM systems. Most projects rely on rigid economic thresholds and have demonstrated repeatedly that these guidelines are not flexible enough to account for the many changing factors of pest/crop systems. Several projects employ sliding thresholds and static decision-making models which vary with respect to crop maturity, days to harvest, moisture stress, beneficial insect density, etc. Timing (or phenological) models are used to predict critical events in the life cycle of insect pests which allows more precise timing of control strategies and also aids scouts in scheduling sampling activities. Development of such models is hampered by a lack of real-time weather data and knowledge of weather-dependent population parameters. More dynamic decision-making models are being developed which couple the population dynamics and feeding potential of the insect pest to the growth, development, and compensatory ability of the crop. Considerable work on key population processes must be done before models of this type can be developed. Especially needed is research aimed at developing plant models that describe the effects of insects on yield.

Information delivery systems include the traditional extension mechanism along with more modern telecommunication and computerized advisory networks. The main problem associated with implementing computerized delivery systems is the lack of decision-making models and alternative management strategies.

Department of Entomology, University of Maryland, College Park, MD 20740.